(54) Title: POLYMERIC MATERIALS FORMED USING BLENDS OF ELECTRON DONORS

Plot of Crystallinity (ΔHm) versus MFR Capability

(57) Abstract

A method of forming a polymer that simultaneously provides an improved level of impact resistance and processability in which a α–olefin monomer is subjected to polymerization in the presence of a Ziegler–Natta catalyst system and a blend of electron donors including dicyclopentyldimethoxysilane (DCPMS) and propyltriethoxysilane (PTES). The polymer so formed will have a relationship between a first melt flow rate of a homopolymer formed by polymerizing a α–olefin monomer in the presence of a Ziegler–Natta catalyst system and a first electron donor (MFR(a)), and a second melt flow rate of a homopolymer formed polymerizing a α–olefin monomer in the presence of the Ziegler–Natta catalyst system and a second electron donor (MFR(b)), is defined by the equation: $1.2 \leq \log[MFR(b)/MFR(a)] \leq 1.4$.

POLYMERIC MATERIALS FORMED USING BLENDS OF ELECTRON DONORS

FIELD OF THE INVENTION

5   This invention relates to novel, high flexural moduli polymeric materials, i.e., in situ polymerized polypropylene homopolymers, formed by a single stage polymerization process conducted in the presence of a blend of electron donor materials. These novel polypropylene homopolymers can be further used to make high impact polypropylene copolymers. In particular, the present inventors have

10   discovered that by using a blend of a first donor material and a second electron donor material each having different hydrogen responses and stereoregulating properties, an olefin polymer exhibiting an unusually good balances of impact resistance, flexural strength and processability can be provided.

BACKGROUND OF THE INVENTION

15   The physical properties of homopolymers of propylene formed by typical Ziegler-Natta polymerization are highly dependent on the stereoregularity of the polymer itself. Highly stereoregular polymers are generally crystalline, provide desirable high flexural moduli and are formed with a suitable choice of electron donor. These highly crystalline polymers also display high melting points, but

20   innately exhibit low melt flow rates (MFR) that render them generally unsuitable for applications that require high processing rates, such as in injection molding, oriented films and thermobond fibers. Further, conventional polypropylene homopolymer and copolymer products formed from highly crystalline polypropylenes lack sufficient impact resistance for many intended uses.

25   The addition of various electron donor materials to Ziegler-Natta catalysts has been known to influence the degree of stereoregularity in polypropylene homopolymers and copolymers. Generally, a single base catalyst (e.g., a magnesium chloride supported base Ziegler-Natta catalyst) can be used in combination with any number of electron donor materials, each of which, or

30   combinations of which, will lead to a specific level of stereoregularity and MFR.

One of the properties of electron donors is that the polypropylene MFR, at the same reactor hydrogen level, decreases with increasing polypropylene stereoregularity caused by the donor. Additional hydrogen is required to reach desirable MFRs when highly stereoregulating donors are employed.

5   Use of the term copolymer herein, is intended to mean those polymeric materials often known as impact copolymers. Impact copolymers typically include homopolymer polypropylene (homo PP) and an ethylene-propylene copolymer component. All references to the term copolymer are intended to include only impact copolymers (ICP) and not statistical or random copolymers.

10   The production of such ICP's is discussed in Polypropylene Handbook, pg. 92, Hansen Publishers.

This relationship between stereoregularity and MFR poses a problem in processes that have hydrogen pressure limitations. In polypropylene manufacturing plants, hydrogen is used for as a chain transfer agent, which

15   controls the molecular weight of the polypropylene. Molecular weight (MW) of the polypropylene decreases, i.e., the MFR of the polymer increases, with hydrogen concentration in a polymerization reactor. The phrase "MFR/hydrogen response" is typically used to express the efficiency of hydrogen as a chain transfer agent in the polymerization catalyst system process. A catalyst system

20   with higher MFR/hydrogen response will generally produce higher MFR polypropylene at a fixed hydrogen concentration. The maximum MFR in the plant or process is defined by the MFR/hydrogen response of the catalyst system and the maximum H_2 levels achievable. Higher MFR polypropylene has been required for larger scale injection molding processes producing items such as

25   automotive or appliance parts. Such MFR's are typically in the range of from 30-100 dg/min. for copolymers, and 75- 180 dg/min. for homopolymers.

On the other hand, polypropylene with higher crystallinity also has been required to enhance the stiffness and heat distortion temperature of the above discussed products. Crystallinity of polypropylene is defined by the catalyst

30   system. To compare the ability of catalyst systems to produce higher crystallinity

polypropylene, crystallinity of the polypropylene at fixed MFR can be used,

because crystallinity of polypropylene increases with MFR of the polypropylene.

Crystallinity is usually evaluated with heat of fusion (defined herein by (ΔH_m) or

alternatively heat of melting) from DSC (Differential Scanning Calorimeter)

5   measurements.

Polypropylene manufacturers have exerted substantial efforts over the past

few years to develop a catalyst system which has both higher MFR/hydrogen

response and the ability to produce higher crystallinity polypropylene. Higher

MFR polypropylene with higher crystallinity is, for example, applied to

10   automotive applications because larger scale injection molded parts with higher

stiffness are required.

In processes wherein the desired hydrogen pressure cannot be reached, a

more hydrogen responsive donor material must be used. However, the use of such

donor materials leads to the formation of less stereoregular polypropylenes with

15   more amorphous polypropylene by-products, producing polypropylenes that lack

sufficient flexural moduli for the intended uses of an automotive trim part. Thus,

processes that have hydrogen pressure limitations pose a problem because the

final achievable MFR will be determined by the choice of electron donor, which in

turn determines the level of polypropylene stereoregularity in the final product.

20   U.S. Patent No. 5,652,303 ('303) to Ishimaru et al. suggests a method of

forming a polypropylene in which propylene monomer is polymerized in the

presence of a catalyst system including a solid titanium based Ziegler-Natta

catalyst having an internal electron donor component, an organoaluminum

compound co-catalyst and a blend of at least two electron donors including an

25   electron donor (A) and an electron donor (B) wherein a relationship between the

MFR (a) of homopropylene obtained by using electron donor (A), together with

the specified titanium catalyst and organo-aluminum co-catalyst; and the MFR (b)

of homopropylene obtained by using electron donor (B), together with the same

catalyst and co-catalyst is defined by the equation:

30                          $\log [MFR(b)/MFR(a)] \geq 1.5.$

The use of a blend of two such electron donors purportedly leads to a broader molecular weight distribution (MWD), exemplified in '303 by MWD's in the range of 6.28 to 8.25, comparative examples ranging from 3.99 to 4.08. The broadening of the MWD allegedly leads to a polymer providing an improved processability.

Therefore, it would be highly desirable to synthesize polypropylene homopolymers in a single stage, in situ polymerization process that forms homopolymers that display both high flexural moduli and high MFRs. The present inventors have discovered that polymerization of an α-olefin in the presence of certain magnesium supported, titanium-base Ziegler-Natta catalyst systems and certain blends of electron donors will result in polymers simultaneously providing higher MFRs and higher levels of crystallinity, leading also to high modulus. It has been further found by the present inventors that the use of such blends of electron donors increases both MFR and crystallinity without substantially increasing MWD. The present invention also provides many additional advantages which shall become apparent as described below.

SUMMARY OF THE INVENTION

Novel in situ polymerized materials (e.g., polypropylene) with substantial degrees of crystallinity and high MFRs can be produced in a single stage polymerization conducted in the presence of certain supported Ziegler-Natta catalysts and a blend of two electron donors including about 2.5 to less than 50 mol.% dicyclopentyldimethoxysilane (DCPMS) and greater than 50 mol.% propyltriethoxysilane (PTES) based on total moles % of electron donor.

A method is presented for forming in situ polymerized homopolymer components that have a relatively narrow molecular weight distribution yet display a high flexural modulus indicative of highly crystalline, isotactic polymer, concurrently with a high MFR. Previously, high MFRs were exhibited only by lesser stereoregular polymers having a higher amorphous content than desireable. The method includes the subjection of an α-olefin (e.g., propylene, 1-butene, 1-pentene, 1-hexene, and the like) to a single stage polymerization in the presence of

a supported Ziegler-Natta catalyst and a blend of two electron donors including about 2.5 to less than 50 mol.% dicyclopentyldimethoxysilane (DCPMS) and greater than 50 mol.% propyltriethoxysilane (PTES) based on the total moles of the electron donor.

5   Other and further objects, advantages and features of the present invention will be understood by reference to claims which follow this specification.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a graph plotting MFR at a constant hydrogen pressure versus ΔH_m at a fixed rate, 70 MFR for conventional electron donors used individually and

10   blends containing different ratios of propyltriethoxysilane (PTES) and dicyclopentyl dimethoxysilane (DCPMS) electron donors.

Fig. 2 shows the plot of crystallinity (ΔH_m) as a function of the polymer MFR for the individual donors. This was obtained by carrying out polymerizations with each donor at different levels of hydrogen to vary the MFR.

15   The intersection of the crystallinity/MFR line with the vertical line set at 70-MFR represents the crystallinity at 70-MFR, which is the value used in Fig. 1.

Fig. 3 is similar to Fig. 2, but using four different ratios of propyltriethoxysilane (PTES) and dicyclopentyl dimethoxysilane (DCPMS) electron donors. From the figure, the crystallinity at 70-MFR was also obtained

20   and used in Fig. 1.

DETAILED DESCRIPTION OF THE INVENTION

The homopolymer of the single stage, in situ polymerization process of certain embodiments of the present invention simultaneously display high flexural moduli (nucleated homopolymer exhibiting flexural moduli in the range of 220 -

25   315 K psi, preferably 280 - 315 K psi) (with a ΔH_m in the range of from 95-120 J/g) normally associated with highly crystalline polymers, a high melt flow rates (MFRs) normally associated with less stereoregular polymers and a relatively narrow molecular weight distribution (MWD), generally in the range of from 3-6, preferably 3.5 - 5.5. These novel homopolymer components are formed in a

30   process where, for example, propylene is subjected to a single stage

polymerization in the presence of a Ziegler-Natta catalyst and a blend of two electron donors including about 2.5 to less than 50 mol.% dicyclopentyldimethoxysilane (DCPMS) and greater than about 50 mol.% propyltriethoxysilane (PTES).

5   Certain Ziegler-Natta catalysts useful in the practice of the present invention are a solid titanium supported catalyst systems described in US-A-4990479 and US-A-5159021. Briefly, the Ziegler-Natta catalyst can be obtained by: (1) suspending a dialkoxy magnesium compound in an aromatic hydrocarbon that is liquid at ambient temperatures; (2) contacting the dialkoxy magnesium-

10   hydrocarbon composition with a titanium halide and with a diester of an aromatic dicarboxylic acid; and (3) contacting the resulting functionalized dialkoxy magnesium-hydrocarbon composition of step (2) with additional titanium halide. A particularly suitable solid catalyst component is a catalyst solid sold by TOHO Titanium Company, Ltd. under the trade name of THC-C-133. Such a catalyst is

15   used to exemplify the invention, other titanium supported catalyst systems are contemplated. Other catalyst use mechanisms are contemplated. Including, but not limited to, batch prepolymerization, in situ prepolymerization and other such mechanisms.

Certain supported Ziegler-Natta catalysts may be used in combination with

20   a co-catalyst. The co-catalyst is preferably an organoaluminum compound that is halogen free. Suitable halogen free organoaluminum compounds are, in particular, branched unsubstituted alkylaluminum compounds of the formula AlR_3, where R denotes an alkyl radical having 1 to 10 carbon atoms, such as for example, trimethylaluminum, triethylaluminum, triisobutylaluminum and

25   tridiisobutylaluminum. Additional compounds that are suitable for use as a co-catalyst are readily available and amply disclosed in the prior art including US-A-4990477, which is incorporated herein by reference for purposes of US patent practice. A particularly suitable organoaluminum co-catalyst is triethylaluminum (TEAL).

Electron donors are typically used in two ways in the formation of Ziegler-Natta catalysts and catalyst systems. An internal electron donor may be used in the formation reaction of the catalyst as the transition metal halide is reacted with the metal hydride or metal alkyl. Examples of internal electron donors include

5   amines, amides, ethers, esters, aromatic esters, ketones, nitriles, phosphines, stilbenes, arsines, phosphoramides, thioethers, thioesters, aldehydes, alcoholates, and salts of organic acids. In conjunction with an internal donor, an external electron donor is also used in combination with a catalyst. External electron donors generally affect the level of stereoregularity and MFR in polymerization

10   reactions. External electron donor materials include but are not limited to, organic silicon compounds, e.g. tetraethoxysilane (TEOS), methylcyclohexyldimethoxysilane (MCMS), propyltriethoxysilane (PTES) and dicyclopentydimethoxysilane (DCPMS). Internal and external-type electron donors are described, for example, in US-A-4535068, which is incorporated herein

15   by reference for purposes of US patent practice. The use of organic silicon compounds as external electron donors is described, for example, in U.S. Patent Nos. 4,218,339, 4,395,360, 4,328,122 and 4,473,660, all of which are incorporated herein by reference for purposes of US patent practice. The blend of electron donors of the present invention is a blend of external electron donors used as

20   stereoregulators, in combination with Ziegler-Natta catalysts. Therefore, except when otherwise indicated, the term "electron donor", as used herein, refers specifically to external electron donor materials.

The external electron donors act to control stereoregularity, which affects the amount of isotactic versus atactic polymers produced in a given system. The

25   more stereoregular isotactic polymer is more crystalline, which leads to a material with a higher flexural modulus. Highly crystalline, isotactic polymers also display lower MFRs, as a consequence of a reduced hydrogen response during polymerization. The stereoregulating capability and hydrogen response of a given electron donor are directly and inversely related. The DCPMS donor has a

substantially lower hydrogen response than the PTES donor, but produces a significantly higher level of stereoregularity than PTES.

As shown in Fig. 1, DCPMS is more stereoregulating, and will, at an equal reactor hydrogen pressure, provide a higher level of crystallinity and lower MFR

5   than the lesser stereoregulating PTES donor. The X-axis represents the actual MFR that is obtained when using the specified polymerization donors, with all experiments carried out at 140-mmole of hydrogen, as shown in the experimental section (B). The Y-axis represents the corresponding crystallinity (based on DSC heat-of-melting values, ΔH_m) for a polymer having an MFR of 70 for each

10 specified donor. The Y-values were obtained from a separate set of experiments, where the amount of hydrogen used during the polymerization was varied at different levels, in order to obtain a plot of the MFR versus the crystallinity (Figures 2 and 3). It is important to compare the crystallinity at a fixed MFR value because the polypropylene product applications are designed based largely

15 on MFR specifications , because crystallinity of polypropylene increases with MFR of the polypropylene. For the individual donors, an almost linear plot is obtained, which shows a decreasing crystallinity with MFR, when going from DCPMS to MCMS, PTES, and TEOS, respectively. The use of different ratios of propyltriethoxysilane (PTES) and dicyclopentyl dimethoxysilane (DCPMS)

20 electron donors exhibit a different curve which is outside of the line for the individual donors by themselves. The use of the mixed donor system, starting at the 50/50 mole % PTES/DCPMS and up to 97.2%/2.5% PTES/DCPMS, shows higher crystallinity/MFR balance than for the individual donors.   The dotted line of Fig. 1 shows the surprising and unexpected result of using the specified blend

25 of PTES and DCPMS. Specifically, the dotted line shows that at a constant hydrogen pressure, for any given MFR, a blend of PTES and DCPMS containing 2.5 mol.% to less than 50 mol.% DCPMS and more than 50 mol.% PTES provides a higher level of crystallinity than would be expected from the average hydrogen response of such a blend, represented by the continuum of the solid line of Fig. 1.

This improved degree of crystallinity relative to MFR is not realized when the blend contains less than 2.5 mol.% DCPMS or less than 50 mol.% PTES.

EXPERIMENTAL

5   (A)   DSC (Differential Scanning Calorimetry)

A TA-200/DSC-10 instrument purchased from TA Instruments, Inc. was used to measure the thermal properties of the polymers. 8-13 mgs sample of either a polymer granule or a pelletize sample was placed in the cell and the cell purged with nitrogen at room temperature for five minutes. Then the temperature

10   was raised to 230°C at a heating rate of 50°C per minute. The temperature was held for ten minutes, followed by cooling to 50°C at a cooling rate of 10°C per minute. After reaching 50°C, the sample was again heated to 200°C at the rate of 10°C per minute. The heat of melting was measured and the result is designated as ΔHm.

15   (B) Polymerization Process in a Batch Reactor

In a 2 liter autoclave polymerization reactor that has been thoroughly cleaned, dried, and purged well with nitrogen was charged, by a syringe an 0.15-0.2 mmole silane donor (from a 0.1M solution in hexane). Then 1.5-2.0 mmole of TEAL (from a 1.0 M solution in hexane) was added, and the reactor was

20   blocked off. A specified amount of hydrogen in mmoles was charged from a 300-ml container under high hydrogen pressure. Catalyst in the amount of 8-15 mgs catalyst solid was charged into the reactor by pushing through the catalyst feed tube about 250-cc of liquid propylene. This was followed by introducing 1000-cc of liquid propylene. The reactor temperature was raised from room temperature to

25   70°C, and the polymerization reaction was allowed to continue for one hour. After the polymerization period, the excess propylene was vented out of the reactor and the remaining polymer was collected and dried under a vacuum oven. The polymer was pelletized with 500 ppm butylated hydroxy toluene (BHT) and samples were taken for MFR, MWD molecular weight distribution, and DSC

30   measurements.

Tables I, II and III show the results the polymerization used to generate

Figures 1, 2, and 3.

Table I

Effects of Donor Type on PP-Crystallinity (ΔHm) and MFR-Capability

Sample No.	Donor Type	H2(mmole)	MFR	ΔHm (J/g) @ 70-MFR*
18270-87	DCPMS	140	3.43	119.8
19987-125	MCMS	140	19.5	113.8
18270-37	PTES	140	59.2	110.0
11373-135-32	TEOS	140	229.9	107.0

*Derived from Figure 2

Table II

Effects of Mixed-Donor Type on PP-Crystallinity (ΔHm) and MFR-Capability

Sample No.	Donor Type (Mole %)	H2(mmole)	MFR	ΔHm (J/g) @ 70-MFR*
19987-84	97.5%PTES/2.5% DCPMS	140	73.9	111.0
19987-54	90% PTES/10% DCPMS	140	31.5	116.0
19987-85	75% PTES/25% DCPMS	140	12.8	116.4
1--87-83	50% PTES/50% DCPMS	140	8.47	117.6

*Derived from Figure 3

Table III

Effects of Mixed-Donor Type on PP-Crystallinity (ΔHm) and MFR-Response

Sample No.	Donor Type	H2(mmole)	Actual MFR	ΔHm (J/g) of Actual MFR
11373-136-03	100% DCPMS	75	0.93	107.2
11373-135-27	"	159	4.10	112.0
11370-133-30	"	375	16.80	115.5
11373-136-11	100% MCMS	75	6.00	106.1
17942-005-21	"	278	39.80	112.3
18270-39	100% PTES	30	6.2	101.5
18270-37	"	140	59.2	109.8
18270-51	"	183	112.4	111.5
11373-135-29	100% TEOS	37	26.4	97.4
11373-135-32	"	140	229.9	107.0
17942-05-16	"	187	321.1	110.4
19562-78	97.5%PTES/2.5 %DCPMS	78	18.20	108.0
19987-84	"	140	73.90	110.7
19562-80	"	209	162.00	113.5
19562-168	90% PTES/10% DCPMS	47	3.59	109.1
19987-54	"	142	31.50	113.9
19562-76	"	235	87.20	116.6
19987-66	75% PTES/25% DCPMS	147	12.00	112.6
19562-140	"	281	47.60	115.5
PPlant/Condition E	50% PTES/50% DCPMS	500 ppm to total Propylene	0.12	105.3
1965-144	"	243	25.90	115.7

5   Some polymer MWD results are tabulated in Table IV.

Table IV

Polymer MWD By GPC

10

Sample No.	Donor Type (Mole %)	H2(mmole)	MFR	MWD
19697-54	DCPMS	279	2.72	3.37
	"	-	8.8	4.44
19697-29	PTES	100	42.6	3.01
	"	-	101	3.95
	90% PTES/10% DCPMS	-	87	4.53

The relationship of MFR response of the PTES donor with respect to the DCPMS when polymerized under the same hydrogen concentration and using the specified THC-C-133 catalyst is shown the Table V below.

Table V

MFR Ratio Relationship Between Using PTES and DCPMS

Sample No.	Donor Type (Mole %)	MFR at 140-mmole H_2	MFR at 233-mmole H_2	Log (MFRb/MFRa)
18270-87	DCPMS	3.43 = a		1.24
18270-37	PTES	59. 2 = b		
20565-153	DCPMS		13.3 = a	1.22
20864-47	PTES		222= b	

The results shown in Table V show that for the two levels of hydrogen concentration used during the polymerization, both values obtained from calculating the Log (MFRb/MFRa) as an MFR-response relationship index from the donors PTES (b-donor) and DCPMS (a-donor) are less than 1.35. And therefore these values are in a region not described by Ishimaru in US 5,652,303.

The following Table VI illustrates the relationship of ΔHm with other cyrstallinity measurements such as heptane insulubles (%HI) and polymer isotactic sequence sequence length (MRL-meso run length) as measured by NMR.

Table VI

Relationship Between ΔHm with HI and MRL

Sample No.	DCPMS (mmole)	H2 (mmole)	MFR	ΔHm (J/g)	HI (%)	MRL NMR
18270-12-19	0	75	87.3	67.44	58.5	52
18270-12-26	0.006	75	1.6	88.71	96.6	130
18270-12-25	0.02	75	1	103	98.3	254
18270-06-09	0.20	75	1.9	104.2	98.6	366
18270-12-23	1.00	75	0.8	106.4	99.0	462

The results in Table VI show that the heat of melting (ΔHm) increases with increasing HI and MRL, which are both well known measures of polymer crystallinity.

In general, the catalyst system and donor blend are chosen such that a
5   relationship between a first melt flow rate of a homopolymer formed by polymerizing an alpha-olefin monomer in the presence of a Ziegler-Natta catalyst system and a first electron donor (MFR (a)), and a second melt flow rate of a homopolymer formed by polymerizing an α-olefin monomer in the presence of the Ziegler-Natta catalyst system and a second electron donor (MFR (b)), is
10 defined by the equation;

$$1.2 \leq \log [MFR(b)/MFR(a)] \leq 1.4.$$

Preferably the α-olefin is chosen from the group consisting of a propylene, 4-methyl-1-pentene, 1-hexene, 1-butene, 1-hexene, 1-decene, 1-dodecene, 1-nonene, and mixtures thereof. Where a copolymer is made, the comonomer may
15 include ethylene.

Propylene is the preferred α-olefin.

DCPMS is the preferred electron donor corresponding to a first electron donor, PTES is the preferred second electron donor.

While preferred embodiments in accordance with the invention have been
20 shown and described, it is to be clearly understood that the same are susceptible to numerous changes apparent to one of ordinary skill in the art. Therefore, the invention should not be deemed to be limited to the details shown and described above, but should be considered to include all changes and modifications that come within the scope of the appended claims.

CLAIMS

We claim:

1.   A method of polymerizing an α-olefin monomer, said method comprising:
    subjecting said α-olefin monomer to polymerization in the presence of a
Ziegler-Natta catalyst system and a blend of electron donors, said blend of
electron donors containing about 2.5 mol.% to less than 50 mol.% of a first
electron donor consisting essentially of dicyclopentyldimethoxysilane (DCPMS)
and greater than 50 mol.% of a second electron donor consisting essentially of
propyltriethoxysilane (PTES).

2.   The method of claim 1, wherein said α-olefin monomer is selected from
the group consisting of: propylene, 1-butene, 1-pentene, 1-hexene, 1-heptene, 1-
octene, 1-nonene, and 1-decene and mixtures thereof.

3.   The method of claim 2, wherein said α-olefin monomer is propylene.

4.   The method of claim 1, wherein said Ziegler-Natta catalyst system
includes a magnesium supported titanium-based solid catalyst.

5.   The method of claim 3, wherein said magnesium supported titanium-based
solid catalyst is a magnesium chloride supported titanium-based solid catalyst.

6.   The method of claim 3, wherein said magnesium supported titanium-based
solid catalyst includes an internal electron donor component.

7.   The method of claim 3, wherein said Ziegler-Natta catalyst system further
comprises an organoaluminum Ziegler-Natta co-catalyst.

8.   A blend comprising a Ziegler-Natta catalyst and a first electron donor and a second electron donor defined by an equation;

$$1.2 \leq \log[MFR(b)/MFR(a)] \leq 1.4$$

wherein MFR(a) is a first melt flow rate of a homopolymer formed by

5   polymerizing an alpha-olefin monomer in the presence of the Ziegler-Natta catalyst and the first electron donor, and wherein MFR(b) is a second melt flow rate of a homopolymer formed by polymerizing an alpha-olefin monomer in the presence of the Ziegler-Natta catalyst and the second electron donor.

10   9.   The blend of claim 8, wherein the first electron donor comprises dicyclopentyldimethoxysilane (DCPMS).

10.   The blend of claims 8 and 9, wherein the second electron donor comprises propyltriethoxysilane (PTES).

AMENDED CLAIMS
[received by the International Bureau on 27 October 1999 (27.10.99);
original claims 1-10 replaced by new claims 1-14 (4 pages)]

1.   A method of forming a polymer comprising:

polymerizing propylene monomers in the presence of a blend comprising a

Ziegler-Natta catalyst, a first electron donor and a second electron donor defined

by an equation;

$1.2 \leq \log [MFR\ (b)/MFR\ (a)] \leq 1.4$

wherein MFR(a) is a first melt flow rate of a homopolymer formed by

polymerizing propylene monomers in the presence of the Ziegler-Natta catalyst

and the first electron donor, and wherein MFR(b) is a second melt flow rate of a

homopolymer formed by polymerizing propylene monomers in the presence of the

Ziegler-Natta catalyst and the second electron donor, and wherein the MFR(a) is

lower than the MFR(b).

2.   The method of claim 1 wherein the first electron donor is

dicyclopentyldimethoxysilane.

3.   The method of claim 1 wherein the second electron donor is

propyltriethoxysilane.

4.   The method of claim 1 wherein the first electron donor comprises from 2.5

to 30 mol.% based upon total mol.% of electron donors.

5.   The method of claim 1 wherein the polymer comprises a polypropylene

homopolymer component.

6.   The method of claims 1 and 5 wherein the polymer comprises a copolymer

component.

7.   In the method of claim 1 wherein the polymer has a MWD in the range

from 3 to

AMENDED SHEET (ARTICLE 19)

8.   In the method of claim 1 wherein the polymer is further defined as an impact copolymer.

9.   A blend comprising a Ziegler-Natta catalyst and a first electron donor and a second electron donor defined by an equation;

$1.2 \leq \log [MFR\ (b)/MFR\ (a)] \leq 1.4$

        wherein MFR(a) is a first melt flow rate of a homopolymer formed by polymerizing propylene monomers in the presence of the Ziegler-Natta catalyst and the first electron donor, and wherein MFR(b) is a second melt flow rate of a homopolymer formed by polymerizing propylene monomers in the presence of the Ziegler-Natta catalyst and the second electron donor and wherein the MFR(a) is lower than the MFR(b).

10.   A method of forming a polymer having a MWD in the range from 3 to 6 comprising:

        subjecting propylene monomers to polymerization in the presence of a Ziegler-Natta catalyst and a blend of at least two electron donors, said blend of electron donors comprising about 2.5 mol.% to 30 mol.% of a first electron donor based on total mol.% of electron donors wherein the first electron donor consists essentially of dicyclopentyldimethoxysilane (DCPMS) and greater than 50 mol.% of a second electron donor based on total mol.% of electron donors wherein the second electron donor consists essentially of propyltriethoxysilane (PTES) and wherein a relationship between the first electron donor and the second electron donor is defined by an equation;

$1.2 \leq \log [MFR\ (b)/MFR\ (a)] \leq 1.4$

        wherein MFR(a) is a first melt flow rate of a homopolymer formed by polymerizing propylene monomers in the presence of the Ziegler-Natta catalyst and the first electron donor, and wherein MFR(b) is a second melt flow rate of a homopolymer formed by polymerizing propylene monomers in the presence of the Ziegler-Natta catalyst and the second electron donor, and wherein the MFR(a) is lower than the MFR(b).

AMENDED SHEET (ARTICLE 19)

11.   A method of forming a polymer having a polypropylene homopolymer component, an ethylene-propylene copolymer component comprising:

selectively polymerizing propylene and ethylene monomers in the presence of a Ziegler-Natta catalyst and a blend of at least two electron donors, said blend of electron donors comprising about 2.5 mol.% to 10 mol.% of a first electron donor based on total mol.% of electron donors wherein the first electron donor consists essentially of dicyclopentyldimethoxysilane (DCPMS) and greater than 50 mol.% of a second electron donor based on total mol.% of electron donors wherein the second electron donor consists essentially of propyltriethoxysilane (PTES) and wherein a relationship between the first electron donor and the second electron donor is defined by an equation;

$$1.2 \leq \log [MFR\ (b)/MFR\ (a)] \leq 1.4$$

wherein MFR(a) is a first melt flow rate of a homopolymer formed by polymerizing propylene monomers in the presence of the Ziegler-Natta catalyst and the first electron donor, and wherein MFR(b) is a second melt flow rate of a homopolymer formed by polymerizing propylene monomers in the presence of the Ziegler-Natta catalyst and the second electron donor, and wherein the MFR(a) is lower than the MFR(b).

12.   A method of forming a polymer comprising:

polymerizing propylene monomers in the presence of a Ziegler-Natta catalyst and a blend of at least two electron donors, said blend of electron donors comprising about 2.5 mol.% to less than 50 mol.% of a first electron donor based on total mol.% of electron donors and greater than 50 mol.% of a second electron donor based on total mol.% of electron donors wherein a relationship between the first electron donor and the second electron donor is defined by an equation;

$$1.2 \leq \log [MFR\ (b)/MFR\ (a)] \leq 1.4$$

wherein MFR(a) is a first melt flow rate of a homopolymer formed by polymerizing propylene monomers in the presence of the Ziegler-Natta catalyst and the first electron donor, and wherein MFR(b) is a second melt flow rate of a homopolymer formed by polymerizing propylene monomers in the presence of the

Ziegler-Natta catalyst and the second electron donor, and wherein the MFR(a) is lower than the MFR(b).
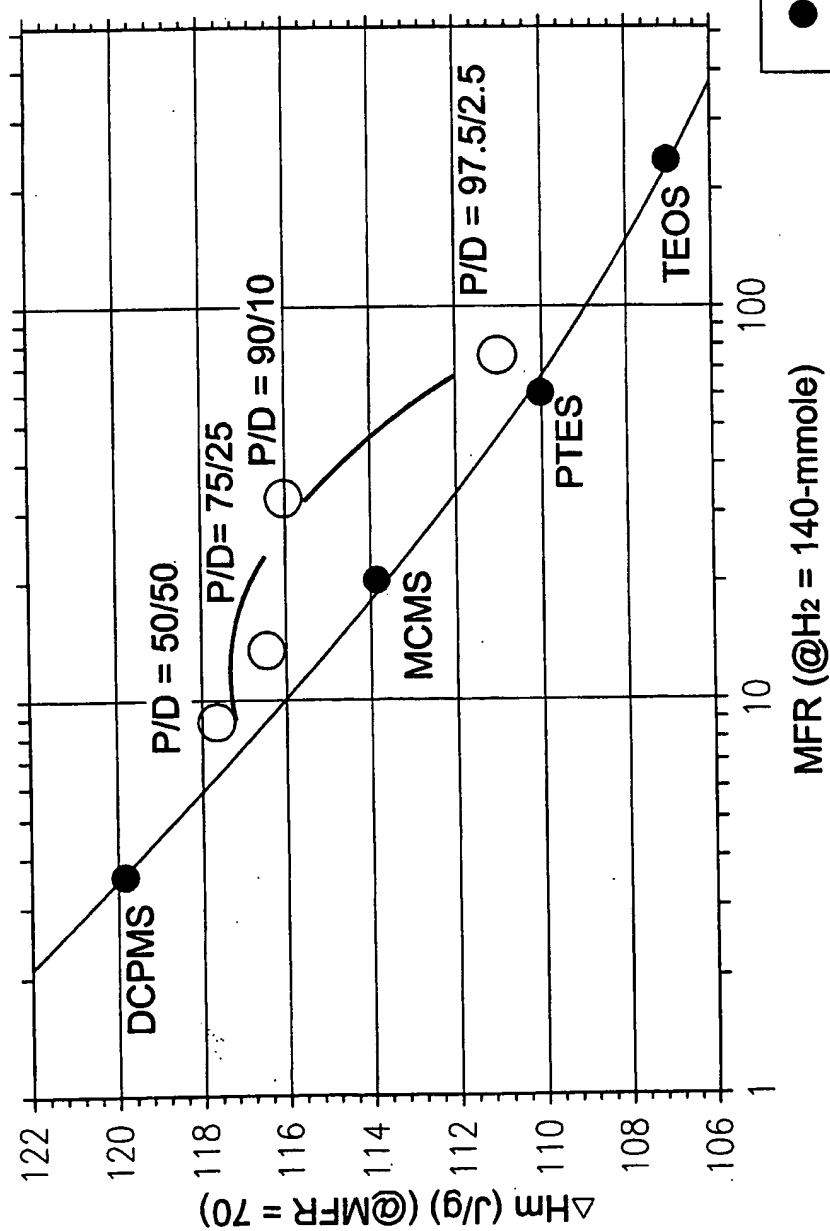
13.   The method of claim 12 wherein the first electron donor is dicyclopentyldimethoxysilane.

14.   The method of claim 12 wherein the second electron donor is propyltriethoxysilane.
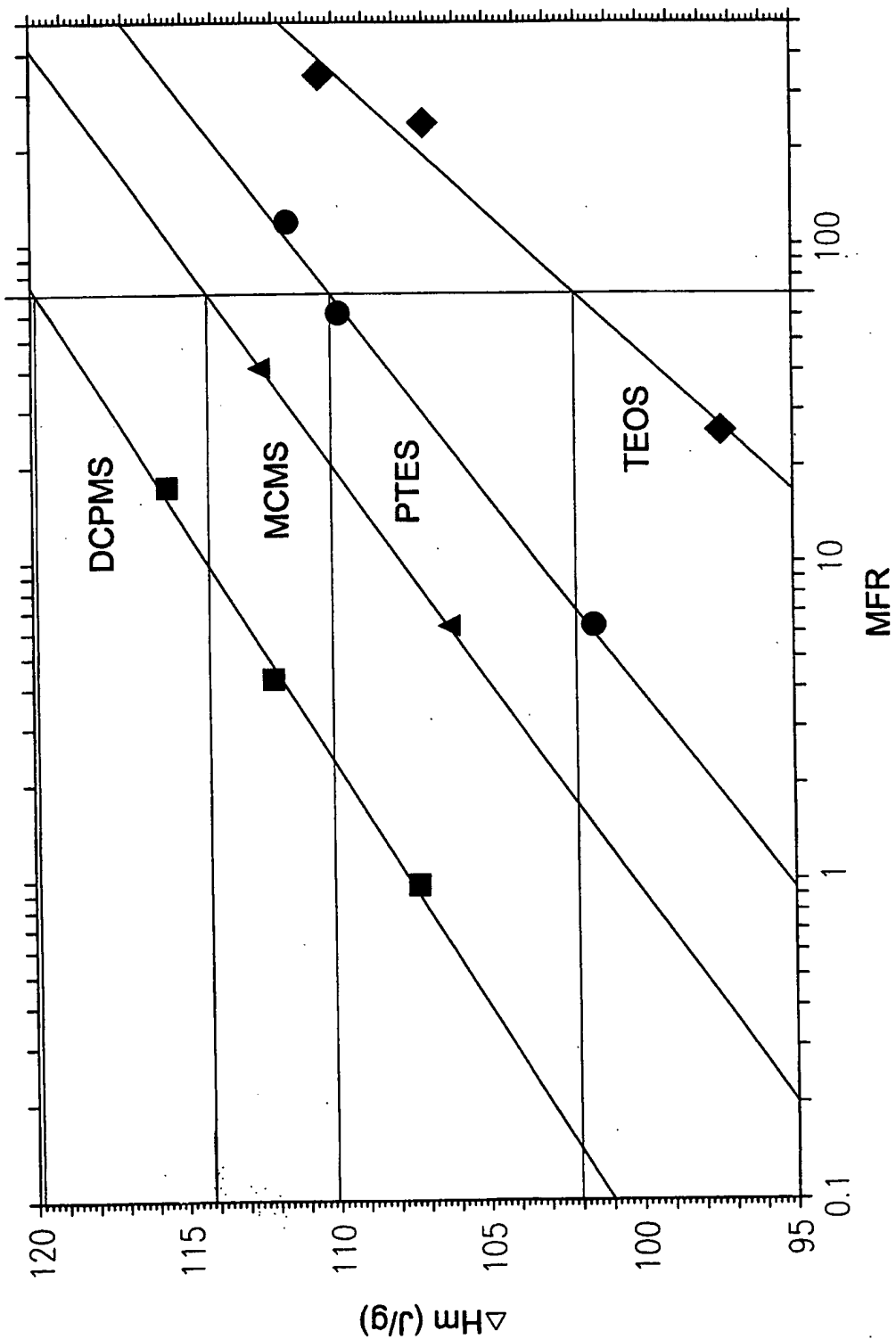
Figure 1

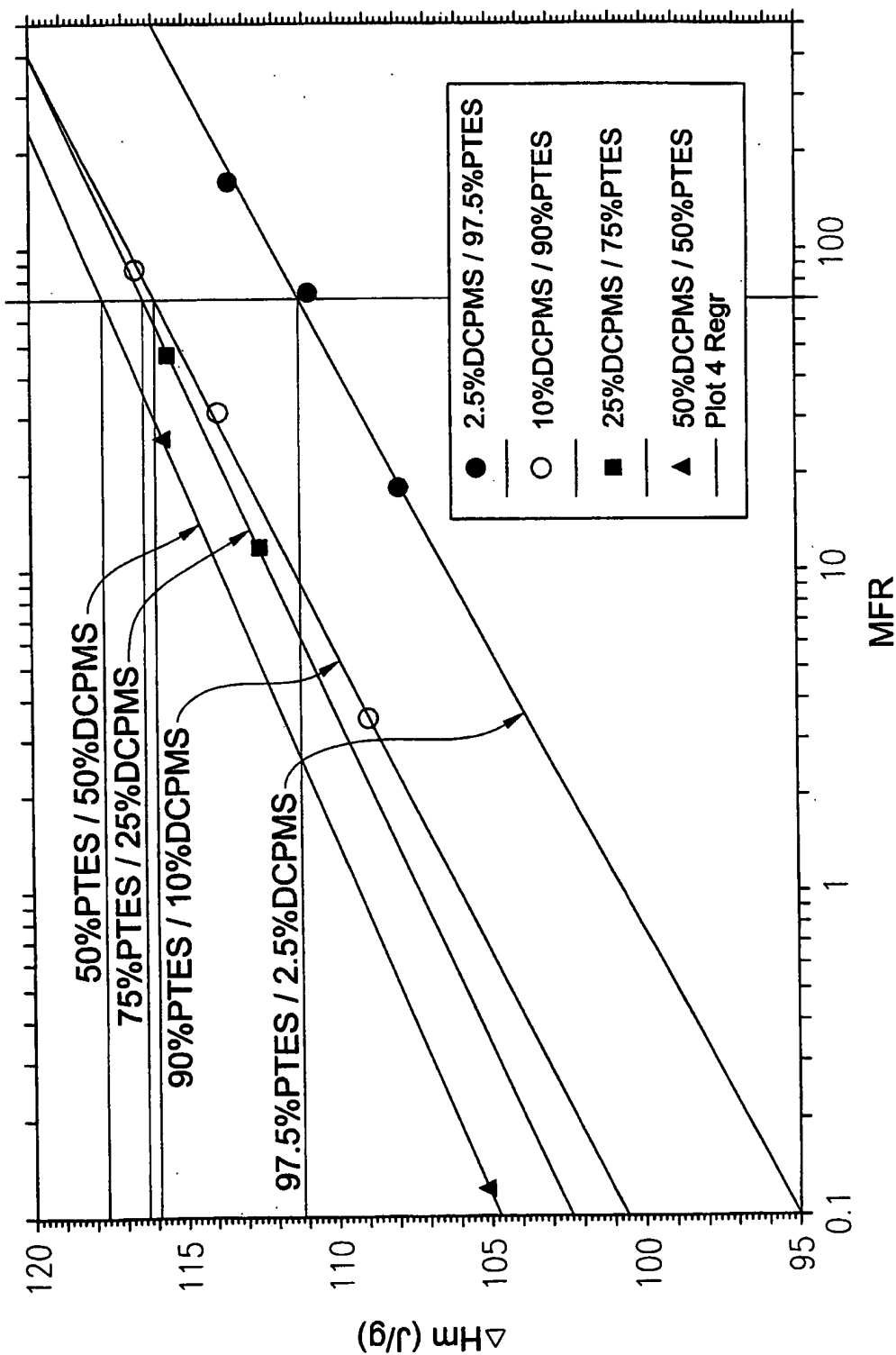Plot of Crystallinity (ΔHm) versus MFR Capability

Figure 2

Plot of Crystallinity (ΔHm) versus Actual MFR

Figure 3

Plot of Crystallinity (△Hm) versus Actual MFR

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6   C08F10/06   C08F4/646

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6   C08F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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| X | Further documents are listed in the continuation of box C. | X | Patent family members are listed in annex. |

* Special categories of cited documents :

"A" document defining the general state of the art which is not
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       which is cited to establish the publication date of another
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       document is combined with one or more other such docu-
       ments, such combination being obvious to a person skilled
       in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 August 1999	02/09/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Gamb, V

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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